

Using Ternary Alloy Additions to Engineer Nitinol Shape Memory Alloys

Completed Technology Project (2015 - 2017)



Project Introduction

Improving travel capabilities is essential in order to further investigative space exploration. For aerospace applications, weight savings is essential. Shape memory alloys (SMAs) are special materials that offer the promise of higher torque to weight outputs, require a lower total part count, and involve less maintenance as compared to conventional hydraulic actuators needed for flight and motor control. This is achieved through the shape memory effect. When a SMA is heated or cooled it undergoes a reversible phase change and the original shape, even against an opposing load, is recovered. This gives these materials the necessary attributes to be a viable replacement material for a variety of aerospace based actuator designs. NiTi alloys, commercially called Nitinol, are the most common SMAs but are limited in applications by either a low transformation temperature, generally between -100°C to 100°C , or dimensional instabilities caused by retained strain through multiple cycling through the transformation temperature. The Ni-rich Nitinol alloys have largely been ignored because of their transformation temperature being well below room temperature. However, recent studies have shown that ternary macro-alloying of Pt, Pd, Hf, Zr, or Au can significantly increase this transformation temperature by more than 200% while retaining good dimensional stability. These changes have been associated with the formation of nanoscale precipitates. To date, the distribution, chemistry, structure and local strain field associated with these nanoscale precipitates and their effect on SMAs have largely been unexplored. In this research, the nanoscale precipitates in Ni-Ti-Zr and Ni-Ti-Hf systems will be comprehensively characterized to optimize the shape memory effect. The effect of ternary macro-alloying on precipitation (size distribution, structure, composition, volume fraction) and localized strain field around the precipitates will be studied. The shape memory transformation will be characterized using differential scanning calorimetry (DSC), and the nano-scale precipitates that control this behavior will be studied using transmission electron microscopy (TEM) and atom probe tomography (APT) with load-bias mechanical testing to determine mechanical performance. These results will yield tailored precipitates that optimize high temperature shape memory properties.

Anticipated Benefits

Shape memory alloys (SMAs) are special materials that offer the promise of higher torque to weight outputs, require a lower total part count, and involve less maintenance as compared to conventional hydraulic actuators needed for flight and motor control. This is achieved through the shape memory effect. When a SMA is heated or cooled it undergoes a reversible phase change and the original shape, even against an opposing load, is recovered. This gives these materials the necessary attributes to be a viable replacement material for a variety of aerospace based actuator designs.



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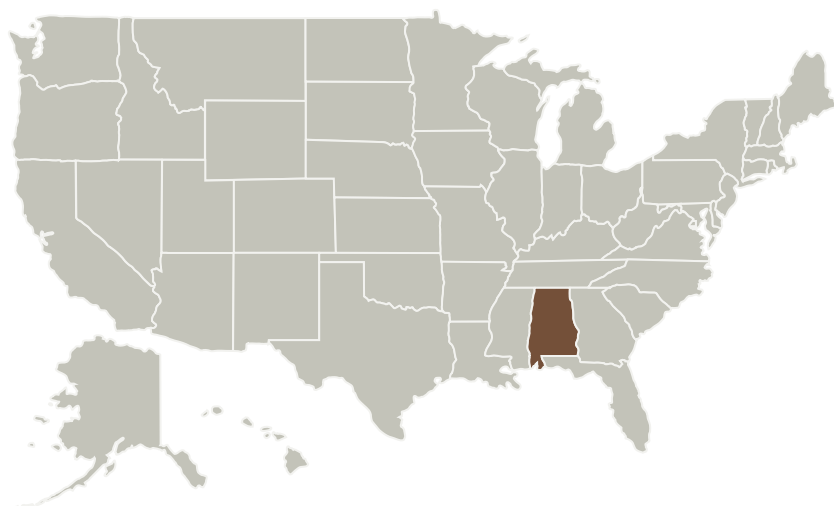
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
The University of Alabama	Lead Organization	Academia	Tuscaloosa, Alabama

Primary U.S. Work Locations
Alabama

Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

The University of Alabama

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Gregory B Thompson

Co-Investigator:

Suzanne M Kornegay

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Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
 - └ TX12.1 Materials
 - └ TX12.1.8 Smart Materials

Target Destination

Foundational Knowledge